Other Research Articles

Economic Expansion Is a Major Determinant of Physician Supply and Utilization

Richard A. Cooper, Thomas E. Getzen, and Prakash Laud

Objective. To assess the relationship between levels of economic development and the supply and utilization of physicians.

Data Sources. Data were obtained from the American Medical Association, American Osteopathic Association, Organization for Economic Cooperation and Development (OECD), Bureau of Health Professions, Bureau of Labor Statistics, Bureau of Economic Analysis, Census Bureau, Health Care Financing Administration, and historical sources.

Study Design. Economic development, expressed as real per capita gross domestic product (GDP) or personal income, was correlated with per capita health care labor and physician supply within countries and states over periods of time spanning 25–70 years and across countries, states, and metropolitan statistical areas (MSAs) at multiple points in time over periods of up to 30 years. Longitudinal data were analyzed in four complementary ways: (1) simple univariate regressions; (2) regressions in which temporal trends were *partialled out*; (3) time series comparing percentage differences across segments of time; and (4) a bivariate Granger causality test. Cross-sectional data were assessed at multiple time points by means of univariate regression analyses.

Principal Findings. Under each analytic scenario, physician supply correlated with differences in GDP or personal income. Longitudinal correlations were associated with temporal lags of approximately 5 years for health employment and 10 years for changes in physician supply. The magnitude of changes in per capita physician supply in the United States was equivalent to differences of approximately 0.75 percent for each 1.0 percent difference in GDP. The greatest effects of economic expansion were on the medical specialties, whereas the surgical and hospital-based specialties were affected to a lesser degree, and levels of economic expansion had little influence on family/general practice.

Conclusions. Economic expansion has a strong, lagged relationship with changes in physician supply. This suggests that economic projections could serve as a gauge for projecting the future utilization of physician services.

Key Words. Physician supply, health care expenditures, health care labor force

Through much of the twentieth century, planners searched for tools that could aid them in defining the future need for physicians. Lacking better means, most adopted normative standards based on experiences in European countries or in areas of the United States that were viewed as having the "right" numbers of physicians (Ginzberg 1989). Following the expansion of medical schools in the 1970s, more quantitative models were developed, principally under the aegis of the Graduate Medical Education National Advisory Committee (Graduate Medical Education National Advisory Committee 1981) and its successor, the Council on Graduate Medical Education (Council on Graduate Medical Education 1994; Weiner 1994; Council on Graduate Medical Education 1996; Greenberg and Cultice 1997). Each was based on the notion that the separate elements of care provided by physicians could be disaggregated, quantitated, and projected into the future. Although differing in the details of design, these various models yielded remarkably similar results, predicting that, by the year 2000, physician supply would exceed demand by 15 to 30 percent. The year 2000 has passed with no overt manifestations of physician surpluses. Indeed, shortages are emerging in many parts of the country and in many specialties, raising the question of whether better models are needed (Cooper 2002).

The Economic Trend

We have taken an alternative approach to physician workforce planning based on analyzing the major trends that underlie the supply and utilization of physician services (Cooper et al. 2002). Three of these trends have been explored elsewhere. They are population growth (Cooper 1994), physician work effort (Kletke, Marder, and Silberger 1990; Schwartz and Mendelson 1990; Hixson 1994), and the contributions of nonphysician clinicians to the provision of "physician services" (Cooper, Henderson, and Dietrich 1998; Cooper, Laud, and Dietrich 1998). The fourth is economic expansion.

For more than 50 years, economic growth in the United States has been closely linked to health care spending, which has outpaced all other major categories of economic activity. In 1959, Seale proposed that a direct relationship might exist between levels of economic development, as reflected by a country's gross domestic product (GDP), and the portion of the economy

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that is devoted to health care (Seale 1959). Over the ensuing years, this thesis was supported by a growing body of literature demonstrating that levels of health care spending could be predicted from GDP or national income with a high degree of accuracy, particularly if temporal lags were also considered (see e.g., Newhouse 1977; Getzen 1990; Pfaff 1990; Getzen and Poullier 1992; Getzen 2000; Okunade and Suraratdecha 2000).

We reasoned that, since labor is the major health care expenditure, and since physicians are a central component of the health care labor force, growth in the utilization of health care workers generally, and of physicians in particular, might correlate with economic expansion. If that is true, economic forecasts might be useful as tools for gauging the future utilization of physician services. The purpose of this report is to examine the interrelationships between economic expansion and size and characteristics of the physician workforce.

Analytic Frameworks. Five analytic frameworks were examined. The first assessed the interrelationships between GDP, health care expenditures, and the health care labor force in the United States and other member countries of the Organization for Economic Cooperation and Development (OECD). The second examined the relationship between GDP and physician supply in the United States over time, based on longitudinal regressions and time series analyses. The third extended these longitudinal analyses to other OECD countries. The fourth shifted the analytic framework to cross-sectional studies among groups of OECD countries and both in the United States and metropolitan statistical areas (MSAs) at particular points in time. Finally, these latter analyses of states and MSAs were extended to assess the major specialty groupings of physicians (medical specialties, surgical specialties, and family/general practice).

METHODS

Data for international comparisons of GDP, health care expenditures, health care employment, and supply of practicing physicians were obtained from the OECD (1999 and 2000). The entire OECD dataset extends from 1960 to 1999, although not all data elements are represented each year for all countries.[1] The Mediterranean countries (Italy, Greece, Spain, and Portugal) were excluded from analyses of physicians because they report "physicians entitled to practice," which includes unknown numbers who were not practicing. For the analysis of longitudinal trends, economic data were expressed as real (inflation-adjusted) national currency units. For cross-national comparisons and graphic comparisons of long-term national tends, GDP was expressed as dollars adjusted for purchasing power parity.

Data for the analysis of active physicians in the United States over the longer period from 1929 to 2000 were obtained from the American Medical Association (AMA) (Pasko, Seidman, and Birkhead 2001, and previous editions), the American Osteopathic Association, and the Bureau of Health Professions (2000), and these data were supplemented by historic sources (e.g., Stewart and Pennell 1960). Economic data were obtained from the Bureau of Economic Analysis (2001), employment data from the Bureau of Labor Statistics (2001), and population data from the U.S. Census Bureau (2001). United States population projections as obtained from the Census Bureau were modified, as reported previously (Cooper et al. 2002). Studies of physicians in states and metropolitan statistical areas (MSAs) were confined to MD patient care physicians, excluding residents, utilizing data from the AMA. Seventeen small MSAs that are home to major medical centers and that had disproportionate numbers of physicians per capita were excluded.[2]

Time series analyses were conducted by comparing the percentage changes occurring across 5- and 10-year segments of time (for health expenditures and employment) and 10-year segments (for physicians), lagged by 0, 5, or 10 years (lag_{0-10}) throughout the period of observation (Makridakis, Wheelwright, and Hyndman 1998). For certain longitudinal regressions, the independent contributions of time trends were *partialled out* by calculating the partial coefficient of multiple determination ($partial\ r^2$) (Rao 1965). Causality between GDP and physician supply was assessed by means of a bivariate Granger causality test (Gourieroux and Monfort 1997). A summary of the statistical tests and their results is presented in Table 1.

RESULTS

GDP, Health Expenditures, and the Health Care Labor Force

Analyses in the United States. Between 1960 and 2000, health care employment in the United States grew more rapidly than the labor force overall, increasing from 8.3 health workers per 1,000 of population (2.8 percent of the labor force) in 1960 to 35.8 per 1,000 of population (7.8 percent of the labor force) in 2000. A time series analysis of the relationship between incremental changes in health employment and incremental changes in GDP revealed a significant correlation when a five-year lag was introduced between changes in GDP and

Table 1: Correlations between GDP or per Capita Income and Differences in Health Employment and Physician Supply

Data Series	*Statistical Analysis*	*Regression Coefficient (R2)*	*p value*	*% Difference in Physicians per 1.0% Difference in GDP**
U.S. Health Employment 1960–2000	Time Series (lag0)	R2 = 0.25	*p* ns	
U.S. Health Employment 1960–2000	Time Series (lag5)	R2 = 0.78	$p < 0.0001$	
U.S. Health Expenditures 1960–2000	Time Series (lag0)	R2 = 0.19	*p* ns	
U.S. Health Expenditures 1960–2000	Time Series (lag5)	R2 = 0.59	$p < 0.002$	
U.S. Physicians 1929–2000	Time Series (lag0)	R2 = 0.02	*p* ns	***
U.S. Physicians 1929–2000	Time Series (lag5)	R2 = 0.21	*p* ns	***
U.S. Physicians 1929–2000	Time Series (lag10)	R2 = 0.93	$p = 0.002$	0.73%
U.S. Physicians 1929–2000	Longitudinal regression (lag10)	***	***	0.81%
Physicians in U.S. States 1970–1996	Cross-sectional regressions	R2 = 0.71	$p < 0.0001$	0.84%
Physicians in U.S. MSAs 1997	Cross-sectional regression	R2 = 0.31	$p < 0.0001$	0.70%
U.S. Physicians 1929–2000	Granger Causality Test (lag5–10)	***	$p = 0.004$	***
OECD Physicians 1960–1995	Time Series (lag0)	R2 = 0.01	*p* ns	***
OECD Physicians 1960–1995	Time Series (lag5)	R2 = 0.13	$p = 0.014$	***
OECD Physicians 1960–1995	Time Series (lag10)	R2 = 0.32	$p < 0.001$	0.53%
OECD Physicians 1975–1995	Cross-sectional regressions	R2 = 0.60	$p < 0.0001$	0.51%
OECD Physicians 1960–1995	Longitudinal regression (lag0)	partial r2 = 0.27	$p < 0.0001$	***
OECD Physicians 1960–1995	Longitudinal regression (lag2,6,10)	partial r2 = 0.38	$p < 0.0001$	***

ns = nonsignificant

MSA = Metropolitan Statistical Area

*% Difference in physicians per 100,000 of population for each 1.0% difference in real GDP or personal income per capita

***Analysis not relevant to this test

subsequent changes in health employment ($R^2_{lag5} = 0.78$, $p < 0.0001$) (Table 1),[3] but no correlation when these two parameters were assessed contemporaneously. Similar observations were made for health expenditures, with a strong correlation when a five-year lag was included ($R^2_{lag5} = 0.59$, $p = 0.002$), as has been noted previously (Getzen and Poullier 1992), but a weak contemporaneous correlation. Since health employment and health expenditures behaved similarly with respect to GDP, it follows that they should track together, and, indeed, significant correlations were observed between these two parameters ($R^2_{lag0} = 0.73$). These findings are consistent with the notion that increases in health employment follow antecedent increases in GDP and are associated with contemporaneous increases in health expenditures.

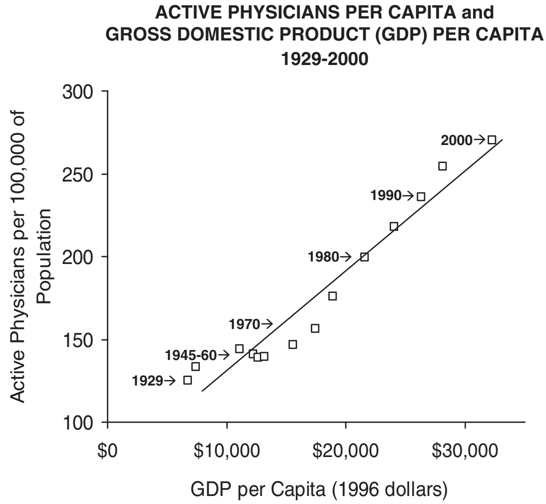
Health Care Employment and Physician Supply. Over this same period from 1960 to 2000, physician supply also grew, but more slowly than health employment overall, a phenomenon that has been documented for more than a century (Kendix and Getzen 1994). As a result, the portion of the United States health care labor force that physicians comprised steadily decreased, from 16.9 percent in 1960 to 7.5 percent in 2000. Similar observations were made in other OECD countries for which adequate data were available.[4] Indeed, a negative logarithmic relationship was observed among OECD countries between the size of the health care labor force and the percentage of each country's labor force that physicians comprised ($R^2 = 0.88$, $p < 0.0001$)[5].

Combining these various observations, the following patterns emerged: (1) health expenditures correlate with GDP and health expenditure growth correlates with the growth of GDP, but with a lag of approximately five years; (2) health employment grows in parallel with the growth of health care expenditures and, like health expenditures, lags behind changes in GDP by about five years; (3) physician supply increases in proportion to health employment but at a slower rate. These interrelationships suggest that changes in the supply of physicians should correspond to changes in the level of the economy overall. This hypothesis was directly examined in the sections that follow.

GDP and Physician Supply over Time: United States

Longitudinal Regression Analysis. The relationship between per capita physician supply and real per capita GDP was studied in the United States over a period of more than 70 years, from 1929 to 2000 (Figure 1). The actual data points tracked the regression line throughout most of this period. However, they deviated sharply in the direction of undersupply in 1960s, a period during

Figure 1: Active Physicians per 100,000 of Population and Gross Domestic Product per Capita (1996 dollars) in the United States, 1929–2000. (Adapted from Cooper et al. 2002.)



which shortages were perceived, but they returned to the trend line by 1980 following an increase in the output of United States medical schools and an influx of international medical graduates (IMGs).

Time Series Analysis. Because longitudinal univariate regressions, such as these, are confounded by multicollinear effects in which time is a factor, their interpretation may be misleading. Time series analyses compensate for this limitation. The analysis that we conducted tested the correlation between percentage differences in GDP and physician supply across 10-year increments of time from 1929 to 1999,[6] both contemporaneously and with lags of 5 and 10 years between changes in GDP and in physician supply. A stepwise increase in the strength of correlation was observed as the duration of lag was increased (Table 1), with no correlation under contemporaneous conditions, a weak correlation with a 5-year lag and a strong and highly significant correlation when a 10-year lag was introduced ($R^2_{lag10} = 0.93$, $p = 0.002$). The slope (*beta*) of this latter relationship was equivalent to a difference in physician supply of 0.73 percent for each 1.0 percent difference in GDP. Reanalyzing the univariate regression in Figure 1 to include a 10-year lag yielded a similar slope, equal to an increase in physician supply of 0.81 percent for each 1.0 percent increase in GDP.

Granger Causality Test. The lagged correlation between GDP and physician supply suggested that the former was predictive of the latter. This hypothesis was further examined by means of a bivariate Granger causality test, which assesses whether previously available information within two parameters can give insight into the future behavior of the parameter of interest. In this case, the analysis tested the extent to which the behavior of GDP over time could explain the future behavior of physician supply independent of the influence that past levels of physician supply have had on its own future levels. When composite lags of 5 and 10 years were introduced into the data from 1929 to 2000, the Granger test[6] indicated that GDP played a statistically significant role in predicting the level of physician supply ($p = 0.004$).

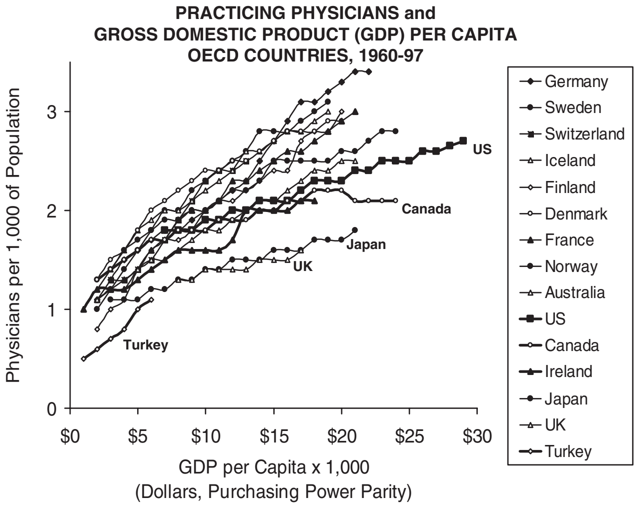
GDP and Physician Supply over Time: OECD Countries

Physician Supply Trends. The relationship between GDP and physician supply was also examined in a group of 14 OECD countries[7] over the period from 1960 to 1997 (Figure 2). Such studies are limited by differences among countries in the structure and organization of health care services, differences in the roles that physicians serve, and even differences in the way that physicians are reported. Nonetheless patterns of growth in physician supply relative to GDP similar to that observed in the United States were found in most other countries.

Several countries warrant special note. First, physician supply in Japan and the United Kingdom grew proportionately less than in the United States. In the case of the United Kingdom, this reflects a long-term policy of capacity constraint, which is now being moderated (Wanless 2002). Second, the rate of growth of physician supply relative to GDP in most other OECD countries was proportionately greater than in the United States. Even in Turkey, whose real GDP in 1997 was the same as that of the United States in 1960, physician supply grew more steeply relative to GDP than in the United States. Finally, Canada, which tracked the United States through the 1980s, is of particular interest because it stringently restricted physician supply over the past 15 years. In the early 1990s, its physician supply data began to deviate from the trend line in the direction of a shortage, as occurred in the United States in the 1960s. In response, Canada recently undertook measures to increase its supply of physicians (Sullivan 1999), as the United States did in the 1970s.

Time Factors and Lags. As mentioned above, simple univariate regressions over time are confounded by multicollinear effects in which time is a

Figure 2: Practicing Physicians per 1,000 of Population and Gross Domestic Product per Capita (Adjusted to U.S. Purchasing Power Parity) among Member Countries of the Organization for Economic Cooperation and Development, 1960–1997.



factor. Therefore, data from countries represented in Figure 2 were analyzed in several ways that reduced the contribution of time. First, a time series analysis was carried out in a manner similar to that described for the United States. It used panel data that were aggregated from ten OECD countries[8] over the period from 1960 to 1995. As had been observed with data from the United States, the correlation between GDP and physician supply was most significant when the incremental changes in GDP occurring 10 years earlier were considered ($R^2_{lag10} = 0.32$, $p = 0.0003$). In contrast, when shorter lags were applied, the correlations were not significant (Table 1). The *beta* of the lag_{10} correlation was equivalent to a difference in physician supply of 0.53 percent for each 1.0 percent increase in GDP.

To further examine the significance of lags, a 10-year lag was applied to the univariate regressions of GDP and physician supply for the countries depicted in Figure 2. The introduction of this lag resulted in a marked increase in data concordance. For example, when assessed contemporaneously (lag_0), 20.5 percent of the data points deviated by more than 10 percent from their respective regression lines, whereas when a 10-year lag was applied (lag_{10}), only 3.8 percent of the data points were outside of this limit. This strong concordance also suggested that substantial deviations were meaningful. Indeed, when deviations were greater than 10 percent shortages, such as those in the United States in the 1960s and in Canada in the 1990s, were perceived and actions to correct them were taken.

A second approach to dealing with the contribution of time to univariate regressions was to analyze the univariate regressions of GDP versus physician from 14 OECD countries[7] by means of the *partial coefficient of multiple determination* (*partial* r^2), which distinguishes the effects of multiple independent variables (e.g., time and GDP) on a dependent variable (e.g., physician supply).[9] Correlating the residuals from a linear regression of GDP on time trend with the residuals from a linear regression of physician supply on time trend yielded a highly significant *partial* r^2 of 0.27 ($p<0.0001$). This correlation was even stronger in a model that included 2-, 6-, and 10-years lags (*partial* $r^2_{lag2,6,10} = 0.38$; $p<0.0001$).

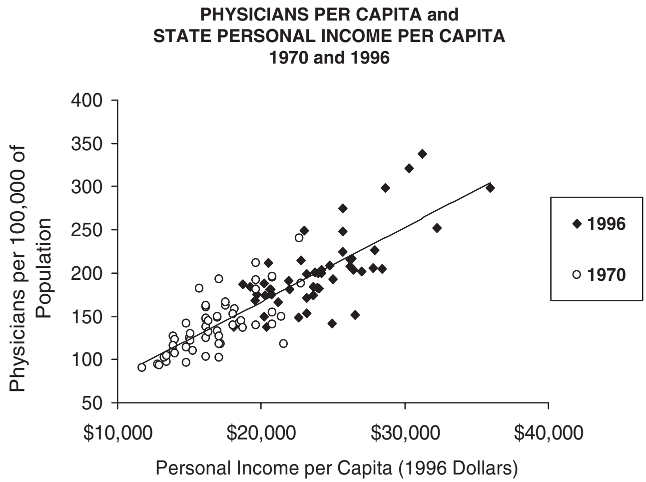
The OECD data are more heterogeneous than the U.S. data, and the analyses of time effects and lags described above required the aggregation of data from multiple countries. These data also span a shorter time period than was available for the United States. Nonetheless, they demonstrated a relationship between GDP and physician supply that is qualitatively similar to the observations made for the United States. Together with the U.S data, they support the concept that a direct, lagged relationship between changes in GDP and physician supply is a general phenomenon in developed countries.

Cross-sectional Analyses of Countries, States, and MSAs

An alternative approach to studying the relationship between physician supply and economic expansion is through cross-sectional analyses among geopolitical units, such as countries, states, or MSAs, at particular points in time. Since each regression uses data from a single time point, correlations are not confounded by time trends. However, temporal characteristics can be discerned by measurements at multiple points in time.

Analysis of OECD Countries. The relationship between GDP and physician supply was examined among 16 OECD countries[10] at five specific time points between 1975 and 1995. Values for R^2 ranged from 0.46 to 0.67. The R^2 of the aggregated data was 0.60 ($p<0.0001$) (Table 1). The *beta* of this regression was equal to a difference in physician supply of 0.51 percent for each 1.0 percent difference in GDP, a value that is very similar to the value of 0.53 percent that had been obtained from a time series analysis of OECD data spanning the somewhat longer period beginning in 1960.

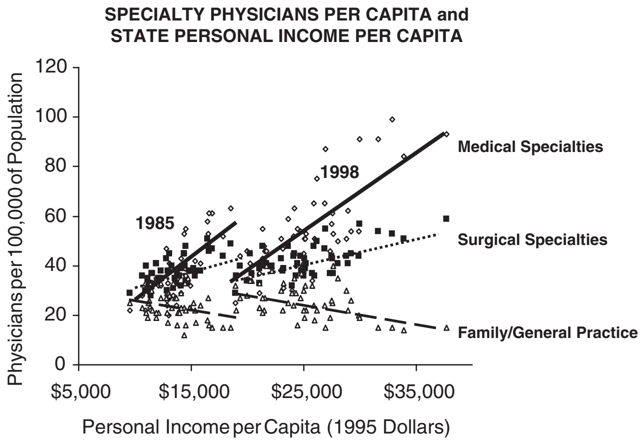
Figure 3: Active Physicians per 100,000 of Population and per Capita Income (1995 Dollars) among States in the United States, 1970 and 1996.



Analysis of Total Physician Supply in States. Figure 3 displays the relationship between physician supply and real per capita income among the states in 1970 and 1996. The earlier data were reported by Reinhardt (1975), and both datasets are expressed in 1996 dollars. For both the combined datasets and for each of these years separately, R^2 was 0.71 ($p<0.0001$). The slopes (*betas*) were consistent with a difference in physician supply of approximately 0.84 percent for each 1.0 percent difference in real per capita income, a value that is similar to the values of 0.73 percent and 0.81 percent that had been obtained from longitudinal analyses of U.S. data over time (Table 1). Similar results were obtained at five intermediate time points between 1970 and 1996. The fact that the *betas* of these cross-sectional analyses remained within a narrow range throughout this period of almost 30 years is consistent with a relationship between physician supply and economic development that is independent of time trends but that persists over time. The persistence of this relationship also reflects a continuing variation in the density of physicians within each state; that is, the per capita distribution of physicians among states did not become more homogeneous over time.

Analysis of Specialties in States. The relationship between levels of per capita income and physician supply among the states was assessed independently for each of the major specialty groupings (Figure 4). The *betas* of these relationships varied significantly. The steepest slope was obtained

Figure 4: Active Physicians per 100,000 of Population in Major Specialty Groupings and per Capita Income (1995 Dollars) among States, 1985 and 1998.



with the medical specialties (general and subspecialty internal medicine and pediatrics).[12] An intermediate slope was seen with the surgical specialties, and the slope was slightly negative for family/general practice. The hospital-based specialties (not shown) followed a pattern intermediate between the medical and surgical specialties. Figure 4, which displays the data for 1985 and 1998, shows that, as income levels increased in states that initially had lower levels of per capita income, the density of specialist supply became similar to those states that, in earlier years, had these higher incomes. At the same time, as wealthier states underwent still further economic growth, their patterns of specialist supply progressed in the direction of the existing trends, with no indication that maximum numbers of medical and surgical specialists or minimum numbers of family practitioners were being reached. Essentially identical results were obtained at four intermediate time points.

Analysis of MSAs. Cross-sectional correlations between per capita income and physician supply were also observed among MSAs in 1997. The R^2 for all active physicians (excluding residents) was 0.31 ($p<0.0001$), a lower value than had been observed among the states, reflecting the greater heterogeneity that is inherent among population clusters of smaller size. However, the slope (*beta*) of this relationship was similar to that observed among states, equivalent to a difference in physician supply of 0.70 percent for each 1.0 percent difference in real per capita income (compared with a value of 0.84 percent derived from the states). The same differential pattern among the major specialty groupings in relation to economic growth that had been observed among the states (Figure 4) also existed among MSAs. Moreover, these patterns persisted when MSAs were subdivided into four major geographic areas (west, midwest, south, and northeast), with the exception that a decline in the density of family practitioners with rising per capita income was unique to MSAs in the northeast, whereas this relationship was flat in the other regions.

DISCUSSION

Throughout this series of studies, per capita physician supply correlated with levels of economic activity, as measured by real per capita GDP or personal income. These correlations were found in a wide range of analytical frameworks, including longitudinal regressions (even when the time trend had been partialled out), time series analyses, and cross-sectional studies at single points in time. Moreover, they were found not only in analyses of data from the United States but also from other OECD countries. They lead to the conclusion that macroeconomic trends, such as GDP and personal income, are good predictors of physician utilization, a formulation that fills a gap left by prior attention to microeconomic trends, such as physician fees or visit volumes, which have had poor predictive value (Luft and Arno 1986).

The macro-trends that we observed had three important characteristics. First, they were consistent across analytic frameworks. Second, they were durable, persisting over periods of 25 to 70 years. Finally, they displayed temporal lags, being most significant when economic changes antecedent to the changes in physician supply were considered.

Consistency. A prominent example of consistency was by the similarity in values for *beta* as derived from longitudinal and cross-sectional analyses. In the United States, these values, which express the percentage change in physician supply that occurs for each 1.0 percent difference in GDP, were within the narrow range from 0.70 percent to 0.84 percent, and values of 0.51 percent and 0.53 percent were obtained in analyses of OECD data (Table 1). Yet these separate analytic approaches need not have yielded such similar *betas*, since they measure quite different phenomena. Longitudinal regressions and time series analyses examine how increases in GDP over time correlate with changes in the rate at which new physicians enter the workforce in excess of those leaving, a process that has significant inertia and, therefore, is associated with temporal lags. In contrast, the cross-sectional analyses examine how fixed numbers of physicians distribute themselves geographically at particular points in time. The facts that the *betas* of both were so similar, and also that the cross-sectional *betas* were so durable over time, are indicative of an underlying relationship between economic development and the demand for physicians that it is operative across geopolitical units and across time.

Durability and the Issue of Maldistribution. The durable nature of the cross-sectional *betas* among states over time also indicates that, despite increases in the number of physicians per capita in each state, variation in the density of physicians among the states, usually referred to as "maldistribution," did not diminish. Previous authors have attributed this phenomenon to a number of factors that influence the way that physicians choose practice locations (Pearl 1925; Fein 1967; Schwartz et al. 1980; Ernst and Yett 1985; Jiang and Begun 2002). Some, such as a community's investment in hospital facilities, medical schools, and health care programs, are directly linked to economic conditions. Others, such as population density, urban characteristics, and the level of education attained by the population, are secondary correlates of economic status. The strongest direct association has been with per capita income, and, as in the current study, this association has been more pronounced for medical specialists than for family physicians. Together with the present study, these observations span almost a century, suggesting that maldistribution of physicians is likely to continue as long as geographic variations in economic conditions persist.

Temporal Lags and Causality. Another significant pattern observed in these correlations was the lag between GDP and physician supply, a factor that sheds light on the sequencing and causality of events. In all cases, correlations were strongest when antecedent changes in GDP were considered. Indeed, most contemporaneous (lag_o) correlations lacked significance (Table 1). The correlations that we observed are most compatible with a model in which changes in both health expenditures and health employment follow changes in GDP with a lag of about 5 years, as others have observed (e.g., Getzen 2000; Okunade and Suraratdecha 2000; Cooper and Getzen 2002a), and changes in the size of the physician workforce follow with a lag of about ten years. This directionality, from growth of GDP to growth in physician supply, was also supported by the results of a bivariate Granger causality test. Although causality is probably even more complex than is revealed by these observations, the patterns that we observed are consistent with a demand for physician services that is causally related to antecedent economic expansion.

This formulation of causality contrasts with a perspective that sees physician supply and utilization not as a consequence of economic expansion but as the cause of health care expenditures (Evans 1974; Rice and Labelle 1989; Grumbach and Lee 1991; Ginzberg 1992; Schroeder and Sandy 1993). A recent study based on simple univariate regressions drew similar conclusions (Brown et al. 2001).[12] However, the notion that physicians cause health care spending is not well supported by the economic literature (see e.g., Folland, Goodman, and Stano 2001), and, as commented upon above, simple univariate regressions are not capable of revealing directionality. Indeed, it is only by means of lags and causality analyses that we were able to discern the cascade of events from economic growth through increases in the health care labor force to an expansion of physician supply.

The Link between GDP and Physician Supply. How does economic expansion play this antecedent role? To answer this question, it is important to consider certain distinguishing characteristics of the health care market. Unlike spending for most other goods and services, the levels of spending for health care are not governed by personal payment at the time of service. There are important exceptions, such as copayments, deductibles, and the payment for uncovered services, such as prescriptions, alternative medicine, and cosmetic surgery, but most spending is through third parties. Therefore, the majority of the decisions that determine the magnitude of health care spending are those that affect the resources or behavior of the responsible organizations and agencies, and most such decisions are made far in advance of spending. Examples include the decisions of employers to enhance health benefits; the decisions of employees to accept health care benefits in lieu of wages; political decisions that affect Medicare, Medicaid, and other federal programs; regulatory actions that restrict insurers and managed care organizations; legislative actions that mandate certain benefits; community decisions to build health facilities or simply to countenance capital expenditures by others; philanthropic decisions to underwrite special treatment centers; and many more.

There is no central decision-making process, but there is a central governing principle. Decisions are made with an awareness of what is "affordable," and what is affordable relates back to some measure (or perception) of aggregate community wealth, as manifested by economic parameters such as GDP or personal income (Fein 1967; Getzen 2000). This is true not only in the United States but also in countries with publicly funded health care systems, including those that rely on gatekeepers (Barros 1998). However, because of lags between economic realities and changes in perception, decisions tend to be delayed. Structural impediments to expanding training or facilities add further inertia. On the other hand, once made, it is often difficult to retreat from these decisions, which leads to periods of excessive spending followed by periods of re-equilibration.

The initial response to an increase in the demand for services in any sector of the economy is usually an increase in the productivity of the existing labor force. However, even though the physician workforce in the United States has grown substantially, its growth has been constrained in relation to demand (Apostolides 1993; Cohen 1995), and the potential for additional productivity is limited. As a result, the first level of response has been to add ancillary staff to assist physicians and to subsume some of their duties (Kendix and Getzen 1994; Cooper, Henderson, and Dietrich 1998; Cooper, Laud, and Dietrich 1998). Yet, even with such added labor, the need for physicians may persist. The second level of response has been to increase the pace of graduate medical education and to modify immigration policy to allow the entry of more IMGs. An associated response in the United States has been the growth of osteopathic medicine. It is only when there is a consensus that shortages will persist despite these adjustments that allopathic medical schools expand, as occurred in the United States in the 1970s and as is now occurring in Canada and the United Kingdom (Sullivan 1999; Wanless 2002.). And it is only when physician supply deviates sharply from its historic relationship with GDP that such a consensus develops. Yet, the yield from such expansion is further delayed because of the length of training. Thus, it is not surprising that there are significant lags between changes in GDP and changes in physician supply.

One consequence of lags is to obscure cause and effect relationships. For example, changes in health care spending that were attributed by Altman and Levitt (2002) to concomitant changes in insurance products, wage and price controls, managed care, and similar interventions proved to relate more strongly to antecedent changes in GDP (Cooper and Getzen 2002a). In a similar manner, past changes in physician supply have been attributed to the easy availability of graduate medical education (GME) funding in the United States, which attracted more IMGs, or to incorrect population projections in Canada, which led to the inadvertent expansion of medical school places in the 1980s. Yet the growth in physician supply in both cases fed a demand that paralleled economic growth. Indeed, had there not been an influx of IMGs in the United States, or had population growth not slowed in Canada, the physician shortages that are now being experienced in both countries would be even more severe (Cooper and Getzen 2002b).

Projections. Over the next decade, per capita GDP is expected to grow at an average annual rate of 1.5 to 2.0 percent (Congressional Budget Office 2000; Health Care Financing Administration 2001). Based on an increase in the demand for physician services of approximately 0.75 percent for each 1.0 percent increase in GDP that these studies demonstrate, the per capita demand for physicians would be expected to increase at an average annual rate of approximately 1.3 percent, a rate that is similar to the growth in job opportunities for physicians projected by the Bureau of Labor Statistics (Braddock 1999). However, these projections of demand substantially exceed the supply of physicians that we and others have projected (Council on Graduate Medical Education 1996; Kletke 2000; Cooper et al. 2002). While the incremental demand for physician services that occurs with each increment of GDP growth may someday diminish, there were no indications in our studies that such a phenomenon has yet occurred. If, instead, past trends persist, efforts will have to be made to increase the nation's capacity for medical education in order to address the shortfall in physician supply that these economic considerations predict (Cooper et al. 2002). To do so is certain to be difficult and costly, and the decision to proceed will more likely be political than statistical. In the past, such decisions were reached when the deviation of physician supply from its GDP trend was of a magnitude that the United States will soon reach. Given the long lead-time necessary to respond, it seems prudent to begin to plan for that eventuality now.

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NOTES

1. The 29 OECD countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.
2. The following small MSAs, which are home to medical centers and which had physician-to-population ratios ranging from 1,701 to 340 (listed in descending order), were excluded: Rochester, Minnesota; Iowa City, Iowa;

Charlottesville, Virginia; Columbia, Missouri; Gainesville, Florida; Greenville, North Carolina; Ann Arbor, Michigan; Galveston, Texas; Raleigh, North Carolina; Madison, Wisconsin; Burlington, Vermont; Lexington, Kentucky; Springfield, Illinois; Lafayette, Louisiana; Little Rock, Arkansas; and La Crosse, Wisconsin.

3. The following countries had adequate data to assess the relationship between GDP, health expenditures, and health care employment over periods of 25 or more years: Belgium, Canada, Finland, Germany, Japan, Netherlands, Norway, Sweden, Turkey, and the United States.
4. Countries with sufficient data to assess the relationship between the size of the health care labor force and physician supply over time included: Australia, Canada, Denmark, Finland, Germany, Hungary, Iceland, Japan, Mexico, Norway, Turkey, and the United Kingdom.
5. Countries with sufficient data to assess the relationship between the size of the health care labor force and the percent of the labor force that physicians included: Australia, Canada, Czech Republic, Denmark, Finland, France, Germany, Hungary, Iceland, Ireland, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.
6. For the time series and Granger analyses of United States physician supply from 1929 to 2000, the data for 1955 and 1960, reflecting constrained production, were excluded.
7. The following countries had sufficient data over 25 years or more to assess the long-term trend relating physician supply to GDP: Australia (patient care physicians including residents), Belgium (all active physicians), Canada (all active physicians), Denmark (all active physicians), Finland (physicians entitled to practice <62 years old), France (all active physicians), Germany (FTE physicians), Iceland (all active physicians), Ireland (physicians entitled to practice <65 years old), Japan (all patient care physicians), Norway (FTE physicians <70 years old), Sweden (all physicians <65 years old), Turkey (all physicians), the United Kingdom (NHS physicians, excluding registrars), and the United States (all active physicians). Data from Turkey were not used in aggregate analyses.
8. Data from the following countries were aggregated for time series analyses: Belgium, Canada, Denmark, France, Germany, Ireland, New Zealand, Norway, Sweden, and the United Kingdom.
9. The simple linear form of this relationship was used since years^2, years^3, or log-years failed to show significant correlations.
10. Cross-national relationships between GDP and physician supply at single points in time were assessed among the following countries: Australia, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Japan, Netherlands, New Zealand, Norway, Sweden, Turkey, the United Kingdom, and the United States.
11. The medical specialties included, in addition to general and subspecialty internal medicine and pediatrics, were dermatology, neurology, and emergency medicine.
12. However, when the time-related data reported by Brown (2001) were differenced to adjust for multicolinearity and to achieve stationarity, the periods of most rapid

increase in physician supply were not associated with above average increases in the growth of health care costs, and the data displayed lags and causal directionality similar to that reported herein.

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